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Art. X.—*Long Range Rainfall Forecasting from Tropical (Darwin) Air Pressures.*

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Darwin has come to occupy a position of singular importance in world meteorology, especially with regard to its air pressure records. These have not only proved valuable as aids to forecasting Indian weather, but show striking correlations with the meteorological phenomena of many other areas, chiefly tropical. It therefore seemed reasonable to hope that since our Southern inland rains are mainly of tropical origin, they also would show some relation to Darwin air pressures. This paper gives the results of an attempt to show whether this is such as to be of use for forecast purposes.

That tropical conditions have a large and direct control over our Southern weather I have already shown by Bulletin 15, Commonwealth Bureau of Meteorology. In this case the minimum temperatures, which give some indication of the total blanketing effect upon the earth's surface of the humidities of the air at all levels of the atmosphere, were used. From these it was deduced that even in winter vast bodies of moist tropical upper air not infrequently invade the continent, and that the rain production of storm systems generally is dependent upon their being met by these invasions. It was found, too, that the semi-permanence of tropical conditions made possible during the winter half of the year forecasts of rain probabilities as much as three weeks ahead, and for this Darwin was the station mainly relied upon.

Of the data up to the present available those provided by the surface air pressures are probably the best for tracing changes in the general atmospheric circulation due, say, to the varying output of solar heat, the interplay of ocean currents and storm systems, etc. And any change in the distribution of pressure over the globe must have its influence upon the development and paths of storm systems, and so upon the rainfall of any locality. It is in the tropical belt that such changes might be expected to reveal themselves first.

This investigation consists mainly of comparisons between the monthly means of air pressure at Darwin, and of the rainfall at ten representative stations in Northern Victoria. These are Swan Hill, Echuca, Yarrawonga, Warracknabeal, Charlton, Bendigo, Shepparton, Dookie, Horsham and St. Arnaud.

As with the minimum temperatures, so with the air pressures in tracing rainfall relations, it will be seen that the tropical control of our Southern inland rains is apparently limited to the

winter half of the year. This is sufficiently well shown by the numbers of times during the 45 years, 1884-1928, in which the individual months show agreements between the departures from normal of the Southern rainfalls and of the Darwin air pressures, counting agreement when lower barometer readings go with higher rainfall, and vice versa. Expressed in percentages of the possible number (45), these are as follow:—January, 55; February, 57; March, 53; April, 45; May, 67; June, 67; July, 71; August, 72; September, 64; October, 73; November, 72; December, 50.

With a view to rainfall prediction the Darwin pressure departures for each pair of months were compared with our Southern rainfalls for the following pair. Agreements, reckoned as above, resulted as follow:—

Darwin Pressure Departures		Northern Victorian Rainfall Departures	Percentage of Agreements p.c.
January-February	with	March-April	47
February-March	„	April-May	50
March-April	„	May-June	67
April-May	„	June-July	76
May-June	„	July-August	77
June-July	„	August-September	82
July-August	„	September-October	70
August-September	„	October-November	71
September-October	„	November-December	50
October-November	„	December-January	55
November-December	„	January-February	59
December-January	„	February-March	56

which are actually better than the synchronous monthly agreements.

As the foregoing suggests, the best forecast results are got by using the Darwin June-July air pressures to indicate the Southern August-September rainfall. This is of economic importance, the August-September rainfall having almost a critical value in cereal production, as well as determining the state of Spring and Summer pastures. The graph, Figure 1, in which pressure departures are reversed, shows the remarkably consistent way in which our August-September rainfall follows the June-July Darwin pressure departures. These curves give the high correlation co-efficient of $-\cdot 79 \pm \cdot 038$. The proportionality between the extreme variations is good enough to suggest possibilities of forecasting drought or flood conditions.

Correlation of the June-July Darwin air pressures with the rainfalls of the three following months taken separately, gave co-efficients of $-\cdot 62$ with August, $-\cdot 58$ with September, and $-\cdot 29$ with October, which confirm the advisability of taking the months in pairs.

The following table gives the forecast relation between the successive two-monthly Darwin air pressure means and the Southern inland rains for the two months following:—

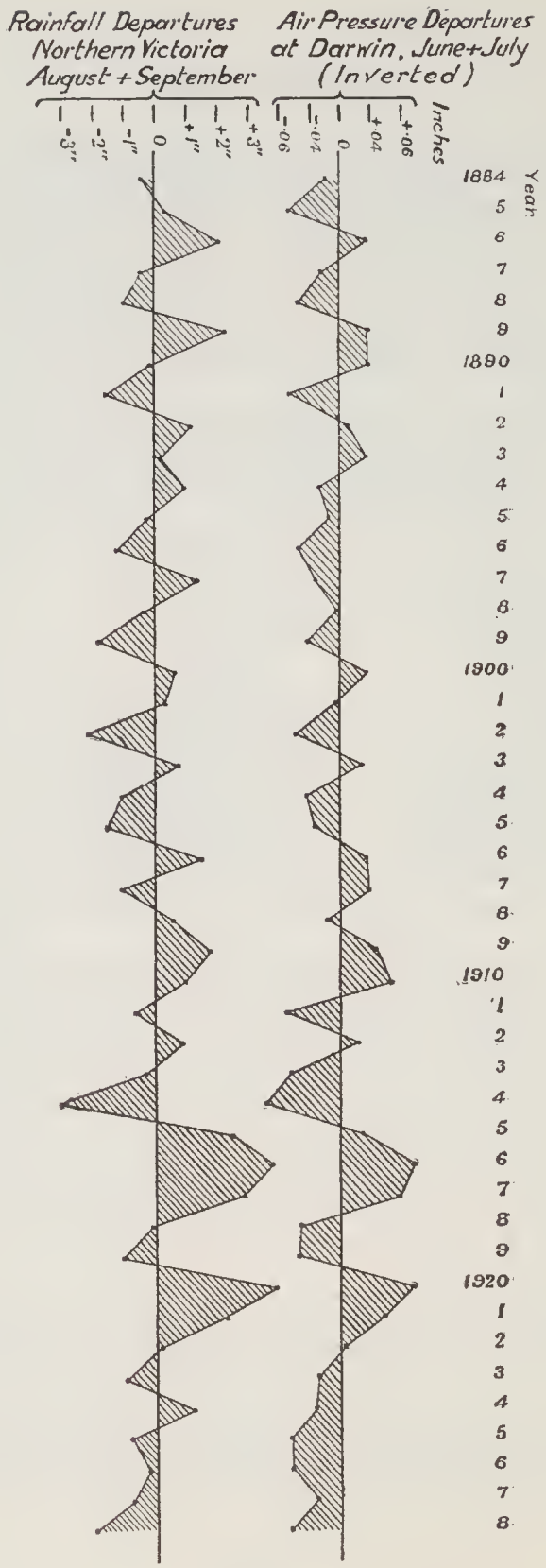
Rainfall Departures
Northern Victoria
August + September
Air Pressure Departures
at Darwin, June+July
(Inverted)
-3"
-2"
-1"
0
+1"
+2"
+3"
-.08
-.04
0
+.04
+.06
Inches
Year
1884
5
6
7
8
9
1890
1
2
3
4
5
6
7
8
9
1900
1
2
3
4
5
6
7
8
9
1910
1
2
3
4
5
6
7
8
9
1920
1
2
3
4
5
6
7
8

FIG. 1.

Pressure Departures at Darwin for		Rainfall over Northern Victoria for	Correlation Co-efficients.
March-April	with	May-June	—·15± ·098
April-May	„	June-July	—·39± ·085
May-June	„	July-August	—·65± ·057
June-July	„	August-September .	—·79± ·038
July-August	„	September-October	—·52± ·073
August-September	„	October-November .	—·37± ·088

In Figure 2, the August-September rainfalls for Northern Victoria (ordinate) are plotted against the Darwin air pressure departures (abscissa) for June-July. Each unit represents for the former one inch, for the latter ten-thousandths of an inch.

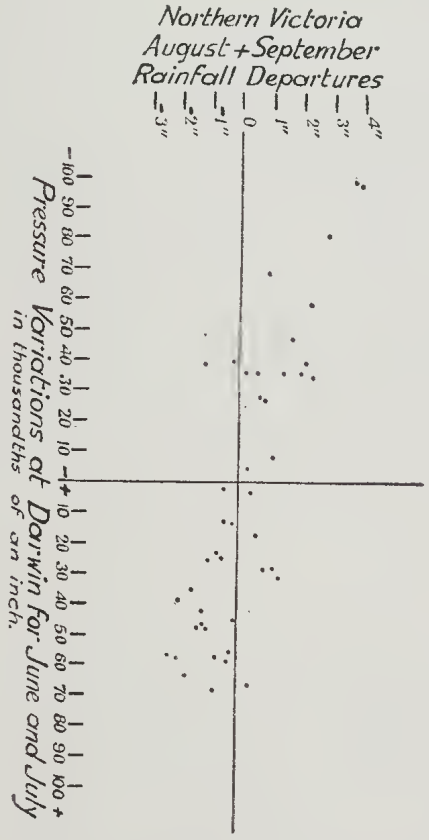

Fig. 2.

The proportionality between them is so well maintained that if we take the rainfall increase as nearly three-tenths of an inch for each one-hundredth of an inch fall in the monthly barometric mean at Darwin, we find for the 45 years under review that forecasts of the amount of rain so based upon the air pressures would have been less, or not more, than one inch in error on 35 occasions,

and over two inches in error on two occasions only. If it were necessary to say only whether the rainfall would be above or below average, the percentage of forecast accuracy would have been 82.

It is to be noted that the rainfall normals used for this paper are based upon the 30-year period, 1885-1914. By using the whole 45 years the principal correlation co-efficients are slightly improved by ·01, i.e., —·79 becomes —·80.